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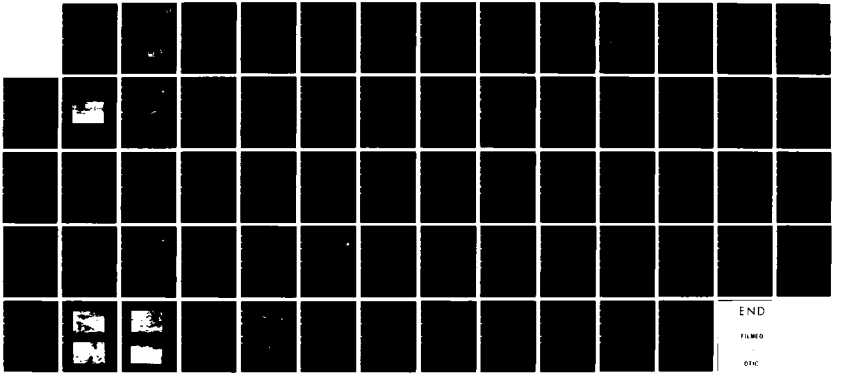

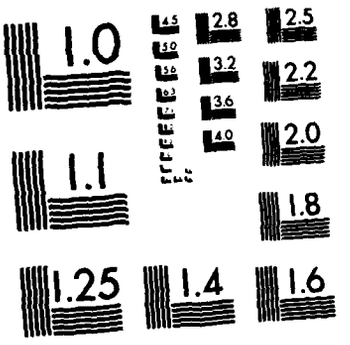

BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS

PATCH RESERVOIR DAM
MA 00122

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST, 1978

UNCLASSIFIED

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Blackstone River Basin
Worcester, Massachusetts

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Patch Reservoir Dam consists of a stone masonry spillway and earth dike. The spillway is about 6 feet high and 70 feet long. The earth dike has a maximum height of 11 feet and is about 200 feet long. Generally, the dike and spillway are considered to be in fair condition. Based on size and hazard classification, the test flood is considered to be one half of the PMF.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED-E

AUG 31 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Patch Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Patch Reservoir Dam would likely be exceeded by floods greater than 13 percent of the Probable Maximum Flood (PMF), the test flood for spillway adequacy. Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty (50) percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non- emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, [illegible] surveillance should be provided.

NEDED-E
Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, City of Worcester, Department of Public Works, 20 East Worcester Street, Worcester, Massachusetts 01604 ATTN: Mr. F. Worth Landers, Commissioner.

Copies of this report will be made available to the public, upon request to this office, under the Freedom of Information Act, thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

PATCH RESERVOIR DAM

MA 00122

BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NEEDS REPRODUCTIONS OF
BLUE PRINT DIAGRAMS
FIGURE 3-4 ? LACKS
FIGURE D-1 S Mine
T. Koop
8/30/84

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00122

Name of Dam: Patch Reservoir

Town: Worcester

County and State: Worcester County, Massachusetts

Stream: Tatnuck Brook - Tributary of Blackstone River

Date of Inspection: July 10, 1978

Patch Reservoir Dam consists of a stone masonry spillway and earth dike. The spillway was constructed around 1896. The spillway is about 6 feet high and 70 feet long. The earth dike has a maximum height of 11 feet and is about 200 feet long. The spillway is located about 800 feet north of the dike. There are no known or visible outlet conduits for the reservoir. There is one plan available for the spillway and no plans available for the dike. There are no specifications or computations available from the Owner, County, or State offices regarding the design, construction, or repairs of the structures at this site.

Due to their age, the spillway and dike were neither designed nor constructed by current approved state-of-the-art procedures. Based upon the visual inspection at the site, the lack of engineering data available, and no evidence of operational or maintenance procedures, there are areas of concern which must be corrected to assure the continued performance of these facilities. Generally, the dike and spillway are considered to be in fair to poor condition. Patch Reservoir Dam has been placed in the "high" hazard category.

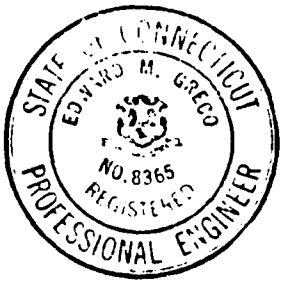
The following are visible signs of distress which indicate a potential hazard at this site: slight to moderate seepage at the downstream toe of the dike, trees and brush on the dike, erosion on the

upstream face of the dike, accumulation of debris in the spillway channel, slight seepage at the west abutment of the spillway training wall, and excavation along the edge of the reservoir.

Hydraulic analyses indicate that the existing spillway can discharge a flow of 1,015 cubic feet per second (cfs) at Elevation (El) 549.8, which is the crest of the dike. Based on size and hazard classifications, in accordance with Corps guidelines, the test flood is one-half the Probable Maximum Flood (PMF). The inflow test flood for Patch Reservoir was calculated as the test outflow from Cook Pond (the next pond upstream in the watershed) MA 00123, plus the one-half PMF for the remaining Patch Reservoir drainage area. This inflow test flood of 8,357 cfs is adjusted for surcharge storage, resulting in an outflow of 7,950 cfs. Since the existing spillway can discharge only 13 percent of the outflow test flood, it is inadequate. The outflow will overtop the dike by about 4.1 feet. In addition, water will discharge through a low area along the reservoir about 200 feet west of the spillway. In the event of overtopping, complete failure of the dike could occur. Due to the potential for overtopping, it is recommended that a definite plan for surveillance and a warning system be developed for use during periods of unusually heavy rains and/or runoff.

It is recommended that the Owner immediately investigate the seepage at the toe of the dike, clear all debris from the spillway, remove all trees from the dike, and install a gated low-level outlet. Also, erosion of the upstream face should be repaired and riprap added to prevent continued deterioration of the dike. It is recommended that the Owner employ a qualified consultant to evaluate the stability of the dike and the seepage at the downstream toe of the dike. Further, a more detailed investigation should be made of the hydraulic and hydrologic aspects of the site.

The above recommendations should be implemented within a period of one year after receipt of the Phase I Inspection Report. An alternative to these recommendations would be draining the reservoir and breaching or removing the dike.



Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

Connecticut Registration
No. 08365

Approved by:

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703

This Phase I Inspection Report on the Patch Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Charles G. Tiersch

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

Fred J. Ravens Jr

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

Saul Cooper

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of

relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PATCH RESERVOIR DAM
WORCESTER, MASSACHUSETTS

SPILLWAY WEIR, DOWNSTREAM VIEW

LOCATION AND DIRECTION OF
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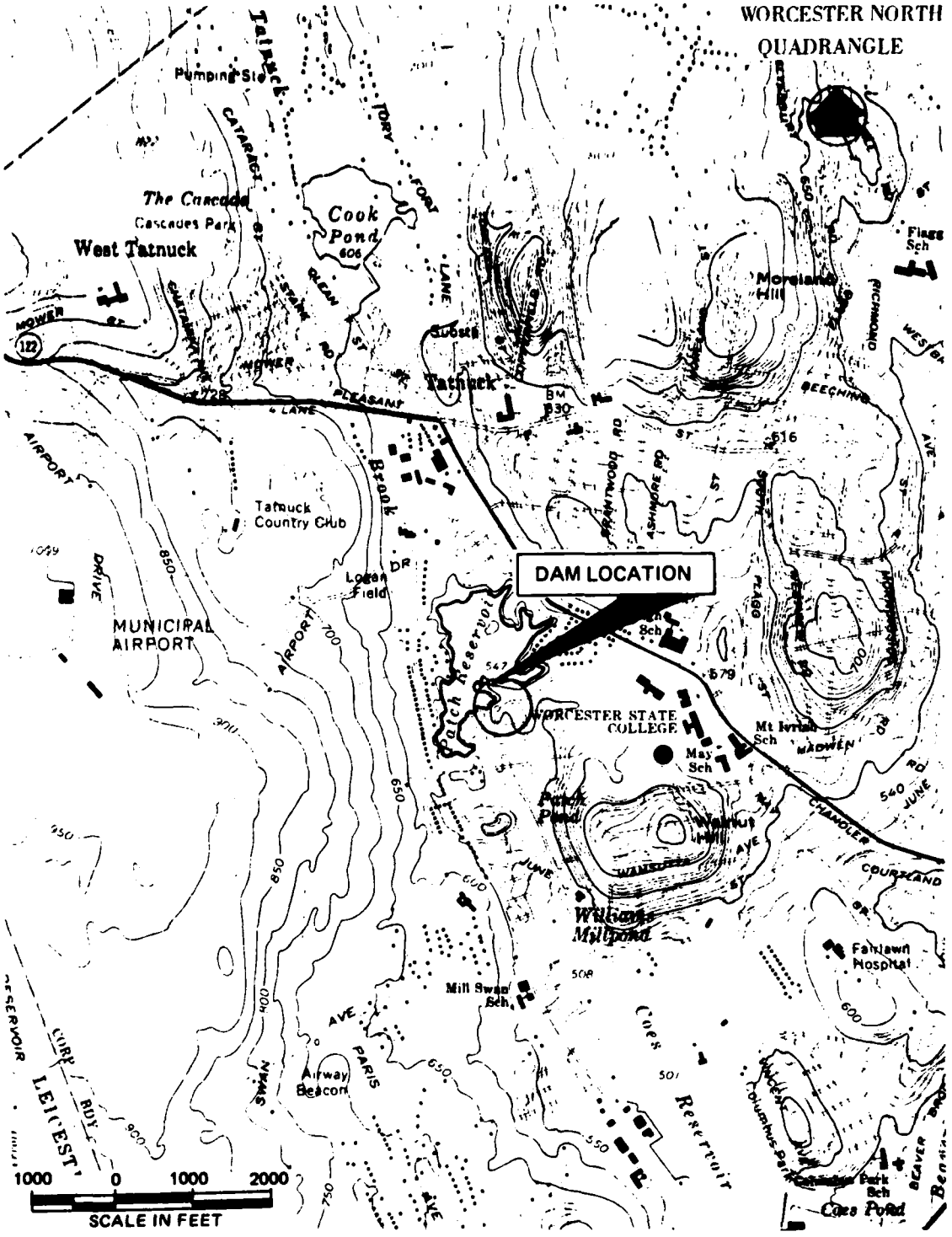
FIGURES IN APPENDIX B



LOCATION MAP - PATCH RESERVOIR DAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

PATCH RESERVOIR

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Metcalf & Eddy, Inc. under a letter of May 3, 1978, from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0306 has been assigned by the Corps of Engineers for this work.

b. Purpose:

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Patch Reservoir is located on Tatnuck Brook in the City of Worcester, Worcester County, Massachusetts. See Figure B-1 in Appendix B, which shows the relationship of the spillway and dike to the reservoir and adjoining streets. Also see Watershed Plan, Figure D-1.

b. Description of Dam and Appurtenances. The spillway at Patch Reservoir is in the form of a cascade type weir comprised of cut granite block steps (see Figure B-4). The spillway weir is 70 feet long at the crest and is 6 feet above the natural streambed. The weir descends in four steps from the crest at El 547 to a fieldstone-lined channel at El 542.2. The natural streambed is at El 540.9 about 25 feet downstream. The section of the upstream approach to the weir that is visible from the crest is paved with fieldstone.

The spillway has mortared-stone masonry training walls. The west training wall is 54.4 feet long and 3.7 feet high. The east training wall, which is 52.5 feet long and 4 feet high, abuts natural ground consisting of shallow and outcropping bedrock. Above the east training wall on the east abutment, the ground slopes up to a residence about 100 feet away.

An earth dike is located about 800 feet southwest along the shore from the spillway (see Figure B-3). The crest of the 200-foot-long dike ranges in elevation from 549.8 to 553.4 and serves as a footpath. The dike is approximately 11 to 13 feet wide at the crest and a maximum of 11 feet high. Both the upstream and downstream slopes of the dike embankment are irregular and overgrown with trees and brush. The slopes vary from 1.5 to 2.5:1 (horizontal:vertical) upstream, and 1.5 to 3:1 downstream.

There are no apparent outlet structures at the dam.

A low area located about 200 feet west of the spillway is shown on Figure B-2 in Appendix B.

This low area appears to have been excavated into natural ground, possibly as a source of fill. The low point is El 552.4 or about 2 feet above the crest of the dike.

c. Size Classification. Patch Reservoir is classified in the "small" category since the dike has a maximum height of 11 feet and the reservoir a maximum storage capacity of 205 acre-feet.

d. Hazard Classification. A dike or spillway failure at Patch Reservoir would release a flood wave that could threaten lives and property in the suburban development located immediately downstream. In addition, it is possible that a failure of the dike at Patch Reservoir could produce a flood wave about 10 feet high, at a point 1,600 feet downstream. This could breach the dam at Patch Pond and jeopardize residences along June Street. For this reason, the dike at Patch Reservoir has been placed in the "high" hazard category.

e. Ownership. The dam is presently owned by the City of Worcester and is under the jurisdiction of the Department of Public Works. Mr. F. Worth Landers, Commissioner, (617-798-8151) granted permission to enter the property and inspect the dam.

f. Operator. There is no known operational equipment at the dam, and there are no known operators of the dam.

g. Purpose of the Dam. The reservoir was formerly used as an ice farm by the Independent Ice Company, and sometime later by the R&H Machinery Co. The last private owner of the dam, Patches, Inc., planned to drain the pond and have the area developed. Instead, it was sold in 1970 to the City of Worcester and is now under the care of the Worcester Conservation Commission and used for recreation.

h. Design and Construction History. The limited information available on the original design and construction of the spillway is included in Appendix B. The original owner was Mr. William Patch; however, the only available

plan, dated 1896, was prepared for the estate of C. Rebboli, Worcester, Massachusetts. This 1896 tracing shows the spillway much as it is today except for the slope of the upstream face. There are no other plans, specifications or computations available from the Owner, or County or State offices relative to the design, construction, or repairs of this spillway. In addition, information is lacking for the dike and for the former gate structure that has apparently been filled.

i. Normal Operating Procedures. There are no operational procedures at the dam. Flow over the spillway is uncontrolled.

1.3 Pertinent Data

a. Drainage Area. The drainage area for Patch Reservoir is estimated to be approximately 5,700 acres (8.9 square miles). About 70 percent of this area is located in the Town of Holden and consists of moderately steep woodland and sparse residential development. Holden Reservoirs 1 and 2, included in this part of the drainage area, are maintained by the City of Worcester for public water supply. Residential development is therefore minimal (see Figure D-1).

The remaining 30 percent of the drainage area is in the City of Worcester and includes the lower part of the Cook Pond watershed. Residential development is more dense in this area, particularly north of Pleasant Street and northeast of Chandler Street. In addition, the runway at the Municipal Airport west of Patch Reservoir serves as an artificial drainage divide.

b. Discharge at the Dam Site. Uncontrolled discharge above El 547 flows over the weir at the spillway, down the cascade, to the paved stream channel below. Immediately downstream from the crest, the channel is bounded by stone masonry training walls for about 33 feet on the east side and 27 feet on the west side. Below that is a narrow, winding stream channel that flows through woodland to Patch Pond, approximately 1,200 feet downstream.

The spillway weir can discharge an estimated 1,015 cfs at El 549.8, corresponding to the low point on the dike and the maximum storage elevation for the reservoir. An inflow test flood of 8,357 cfs (one-half the probable maximum flood) will overtop the lowest point on the dike by 4.1 feet. The spillway has the capacity to discharge only 13 percent of the outflow test flood.

The maximum flood at the dam site is unknown although frequent backyard flooding has been reported by local residents.

As shown on Figure D-1, Patch Reservoir is located downstream of Holden Reservoirs No. 1 and No. 2 and Cook Pond. Flow into Patch Reservoir is dependent upon the storage-discharge characteristics of these upstream reservoirs.

c. Elevation (feet above MSL [Mean Sea Level]). A benchmark elevation of 547.0 at the spillway crest was estimated from a U.S.G.S. topographic map.

(1) Top - Spillway: 547.0
- Dike section: 549.8 to 553.4

(2) Test flood pool: 553.9

(3) Design surcharge (original design): Unknown

(4) Full flood control pool: Not applicable (N/A)

(5) Recreation pool: 547.0

(6) Spillway crest (ungated): 547.0

(7) Upstream portal invert diversion tunnel: N/A

(8) Streambed at centerline of dam: 541.5 (downstream of spillway)

(9) Tailwater: 541.5

d. Reservoir

(1) Length of maximum pool: 2,000 feet

(2) Length of recreation pool: 2,000 feet

(3) Length of flood control pool: N/A

e. Storage (acre-feet)

(1) Test flood surcharge: 210 at El 553.9

(2) Top of dike: 205

(3) Flood control pool: N/A

(4) Recreation pool: 120 (approximate)

(5) Spillway crest: 120

f. Reservoir Surface (acres) (Assume no significant increase in reservoir area with change in elevation from 547.0 to 549.8)

(1) Top dam: 30

(2) Test flood pool: 30

(3) Flood-control pool: N/A

(4) Recreation pool: 30

(5) Spillway crest: 30

g. Dam

(1) Type - Spillway: cut stone blocks
- Dike section: earth

(2) Length - Spillway: 70 feet
- Dike section: 200 feet

(3) Height - Spillway: 6 feet
- Dike section: 11 feet

(4) Top width - Spillway: 1 foot
- Dike section: varies from 11 to 13 feet

(5) Side slopes - Spillway: downstream cascade: 1:1
- Dike section: varies:
upstream 1.5 to 2.5:1
downstream 1.5 to 3:1

(6) Zoning: Unknown

(7) Impervious core: Unknown

(8) Cutoff: Unknown

(9) Grout curtain: Unknown

i. Spillway

(1) Type: Broad crest

(2) Length of weir: 70 feet

(3) Crest elevation: 547 MSL (assumed bench-mark)

(4) Gates: None

(5) Upstream Channel: Flared training walls

(6) Downstream Channel: 70-feet-wide stepped stone spillway to earth channel

(7) Core: Rubble masonry

(8) General: Spillway channel is paved with field stone for a short distance and then natural earth channel.

j. Regulating Outlets. There is no regulating outlet at this dam.

SECTION 2

ENGINEERING DATA

2.1 General. The only available plan of the construction of Patch Reservoir Dam is a 1936 tracing of the spillway plan and cross section dated April 21, 1896. A copy is included in Appendix B. The only other data available for this evaluation were visual observations during inspection, review of previous inspection reports, and conversations with the Owner and personnel from State and County agencies.

We acknowledge the assistance and cooperation of personnel of the Massachusetts Department of Public Works: Messrs. Willis Regan and Raymond Rochford, and of the Massachusetts Department of Environmental Quality Engineering, Division of Waterways: Messrs. John J. Hannon and Joseph Iagallo.

Also, we acknowledge the cooperation and assistance of personnel from the Worcester County Engineer's Office: Messrs. John O'Toole, Joseph Brazauskas, and Mr. Wallace Lindquist - recently retired from county service.

Mr. F. Worth Landers, Commissioner of Public Works for the City of Worcester, granted permission to enter the property and inspect the dam. Messrs. Michael Burke, Richard Grant, and Ed Mara of the Worcester DPW provided background data on the reservoir and dam.

2.2 Construction Records. There are no detailed construction records available.

2.3 Operation Records. No operation records are available, and there is no daily record kept of pool elevation or rainfall at the dam site.

2.4 Evaluation

a. Availability. The availability of data is limited due to the age of this dam.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Validity. The limited engineering data available is considered valid.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The Phase I inspection of the dam at Patch Reservoir was performed on July 10, 1978. A copy of the inspection checklist is included in Appendix A. Periodic inspections of this dam have been made by others since 1925. A partial listing of these inspections is in Appendix B. An inspection by the Massachusetts Department of Public Works was made in January, 1973, and a copy of that report is included in Appendix B. In addition, early inspection records were reviewed at the Worcester County Engineer's Office.

b. Dam. The impoundment structures consist of a spillway and dike section. The spillway is a stepped stone structure. Granite blocks comprising the crest and cascade are in good condition, although slightly misaligned horizontally. There is a small (6-inch) gap in the crest near the east end of the spillway which is the result of a broken corner on a crest block. Although the pond level was slightly below the crest, water was observed flowing through the gap and also leaking from beneath the first two steps of the cascade. Slight seepage was also observed in the wall at the west abutment, just above the level of the downstream streambed.

The shear pins that secure the second row of blocks appear to have been 1-inch diameter, but have been corroded to about 3/4 inch diameter. Continued deterioration of the shear pins could eventually affect the stability of the weir blocks.

The toe of the spillway is paved with irregular fieldstone blocks. Erosion beneath the stones at the toe has caused some settlement. The downstream earth channel is fairly narrow, winding, and stony, and has minor amounts of debris such as tree branches in it.

The training walls at each end of the spillway are mortared fieldstone in generally good condition, although the mortar is missing from the lower stones on the upstream end of the west wall. The walls abut natural ground and are practically overgrown by bushes and trees on the downstream side. There has apparently been some tree cutting on the upstream side of the left abutment.

Above the training wall, on the left abutment, a second retaining wall apparently intended to protect the abutting property has been built of broken concrete slabs. A footpath passes between the two walls.

On the upstream side of the spillway, the bed of the pond is only a few inches below the crest block. There is evidence of a stone pavement, although this is not shown in the old plan of the dam.

The earth dike, located about 800 feet from the spillway, is overgrown with trees on both the upstream and downstream sides, and a footpath runs along the crest. There is no visible slope protection. Seepage was observed along about one-third of the length of the dike, which results in a soft swampy area at the downstream toe. A few animal burrows were noted.

c. Appurtenant Structures. Early inspection reports suggest the evidence of a gated outlet at the dam. It was not visible at the time of inspection. There are no other structures connected with this dam.

d. Reservoir Area. A comparison of a 1960 and 1974 U.S.G.S. topographic map indicated that a large amount of fill has been added in the southern end of the reservoir, west of the dike. Most of the residential development is north of the spillway and generally on the north and west side of the pond. A footpath runs between the spillway and the dike. Although this area is covered with vegetation, trespassing on the slope to reach the water has caused erosion in many parts of the

shore. During the visual inspection, one such eroded low area leading to a small beach was noted. The low area has an elevation about 2 feet higher than the dike.

In the drainage area near the pond, residential development is heaviest north and west of the Reservoir.

e. Downstream Channel. Water flows into the discharge channel below the spillway for about 1,200 feet before entering Patch Pond. Houses are located along the east side of the spillway channel for at least 500 feet downstream. A storm drainage system for residential development enters the channel through a culvert about 400 feet downstream of the spillway. Frequent flooding is reported by the residents. The stream is eroding its banks in several places which causes trees to fall into the channel. The channel generally contains brushes and miscellaneous debris as well.

3.2 Evaluation. The above findings indicate that the dam has several areas of distress which require attention. It is evident that the dam is not adequately maintained and that deterioration will continue unless action is taken. Recommended measures to improve these conditions are included in Section 7.

SECTION 4

OPERATING PROCEDURES

4.1 Procedures. There are no operating procedures at Patch Reservoir.

4.2 Maintenance of the Dam. The dike and spillway are inadequately maintained as evidenced by the condition of the cascade and overgrowth of trees on the dike. The City of Worcester has no regular maintenance program.

4.3 Maintenance of Operating Facilities. There are no operating facilities on the structure. Discharge over the spillway is uncontrolled and there is no other outlet.

4.4 Description of any Warning System in Effect. There are no warning systems in effect at this site.

4.5 Evaluation. Patch Reservoir is in the high hazard category because of the threat to downstream residents in the event of dam failure. The dike and spillway are in fair to poor condition. Due to the potential for failure, a program of operation and maintenance, and a warning system in the event of emergency should be implemented as recommended in Section 7.

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data. Patch Reservoir receives flow from Cook Pond plus 1.8 square miles of tributary area directly below Cook Pond. A Phase I Investigation has recently been completed for Cook Pond (MA 00120). The inflow test flood was based on calculated discharge from Cook Pond plus an estimate of flow from the tributary area directly below Cook Pond. The Probable Maximum Flood (PMF) rate was determined to be 2,350 cfs per square mile for the drainage area below Cook Pond. This calculation is based on the average drainage area slope of 4 percent, the pond-plus-swamp area to drainage area ratio of 5.7 percent, and the U.S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Flow Rates (dated December 1977). Applying one-half the PMF to the 1.8 square miles of drainage area results in a calculated peak flood flow of 2,115 cfs as the inflow test flood. Including the effect of Cook Pond, the total inflow test flood equals 8,357 cfs (939 cfs per square mile). By adjusting the inflow test flood for surcharge storage, the maximum discharge rate was established as 7,950 cfs (893 cfs per square mile), with a water surface at El 553.9.

Flow over the dike crest is predicted to be 3,740 cfs, and flow through the spillway would be 4,210 cfs. The maximum head on the dike would be 4.1 feet with a discharge of 21.2 cfs per foot of width. Depth at critical flow would be at 2.4 feet with a velocity of 8.8 feet per second.

Flow will also occur in the low area shown in Figure B-2. This low area is about 2 feet above the crest of the dike. However, due to the limited size of this area, outflow through this section was not considered in the hydraulic computations. The maximum discharge head on the dike would be slightly reduced if the effect of the discharge in the low area was considered.

The inflow from a 100-year frequency storm was estimated to be 3,410 cfs. After adjustment for surcharge storage, the outflow from the 100-year storm was calculated to be 3,180 cfs which would result in a water surface at El 552, or about 2.2 feet over the dike crest.

Hydraulic analyses indicate that the existing spillway can discharge a flow of 1,015 cfs at water surface El 549.8, which is the crest of the dike. This means that the spillway has the capacity to discharge only 13 percent of the outflow test flood.

b. Experience Data. Hydraulic records are not generally available for this site; however, in conversations with personnel from the Worcester County Engineer's Office, it was noted that the dike was not overtopped in the 1955 floods.

c. Visual Observations. The spillway consists of a 70-foot-long stone masonry spillway which discharges over a cascade into a natural stream channel.

The spillway appears to be in fair condition although some leakage was observed. A storm drainage system enters the channel about 400 feet below the spillway, and frequent backyard flooding was reported by a local resident. Erosion into the channel could reduce the capacity of the channel and increase local flooding.

d. Overtopping Potential. Overtopping of the dike is expected under the test flood of 8,357 cfs (inflow); as noted previously, however, the only available records on overtopping indicate that the dam was not overtopped during the 1955 floods. The pond elevations of the upstream reservoirs are unknown prior to the 1955 storm. The storage effect of these reservoirs would minimize discharge to downstream areas. In the event of overtopping, complete failure of the dike could occur. The resulting flood wave could reach a height of 10 feet at a point 1,600 feet downstream of the dike and be a hazard to life and property.

e. Additional Hydraulic Considerations. As shown on Figure D-1, Patch Reservoir is located downstream of Holden Reservoirs No. 1 and No. 2 and Cook Pond. However, the calculations for a Phase I investigation are based on the U.S. Army Corps of Engineers guide curves which do not entirely consider the storage discharge characteristics of upstream reservoirs. The inflow test flood for Patch Reservoir has included the storage effect of Cook Pond but not Holden Reservoirs No. 1 and No. 2. Therefore, the conclusions on peak flows and dam overtopping should be considered as preliminary only. A more detailed hydrologic and hydraulic investigation should be based on the storage effects of all upstream reservoirs.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. The evaluation of the structural stability of the dike and spillway at Patch Reservoir is based on the visual inspection conducted on July 10, 1978. Based on the observations, as detailed in Section 3, and the evaluation of the hydraulic data, the dike and spillway at Patch Reservoir are considered a hazard. The condition of the structures is unsatisfactory and conventional factors of safety may not exist.

It is recommended that a more detailed investigation be initiated to evaluate the condition of the dike and spillway and the seepage at the downstream toe of the dike.

b. Design and Construction Data. Discussions with the Owner, and County and State personnel indicate that there are no plans, specifications, or computations relative to the design, construction or repairs of the dike at Patch Reservoir. Information on the type, shear strength and permeability of the soil and/or rock materials is nonexistent. One drawing showing details of the original spillway is attached as Figure B-4 in Appendix B.

The spillway structure was built in 1896. The drawing indicates it consists of a rubble masonry core and earthfill on the upstream side, and concrete and dry rubble masonry on the downstream cascade. It appears that the steps are the original granite blocks and that only the upstream slope has been altered. It is not known when the dike embankment was built. As discussed previously, the reservoir shoreline has been recently altered by filling at the southern end.

c. Operating Records. There is no evidence of any type of instrumentation at Patch Reservoir dike or spillway, and there is no indication that any instrumentation had ever been installed. The performance of the spillway and dike under prior loading can only be inferred by physical evidence at the site.

d. Post-Construction Changes. There are no as-built drawings for the existing spillway and dike. The only apparent modifications have been the change in slope upstream of the spillway crest and the arrangement of the iron pins securing the stone blocks on the cascade. Previous inspectors reported on the condition of the outlet gate, but there is no longer evidence of an outlet at the site.

e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with Phase I "Recommended Guidelines" does not warrant seismic analyses.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. Due to their age, neither Patch Reservoir dike or spillway were designed nor constructed to the current approved state-of-the-art procedures. Based upon the visual inspection, and with no engineering data available and no evidence of operation or maintenance, there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the dam is considered to be in fair to poor condition. As noted previously, there are several problem areas: the lack of a regulating outlet; seepage at the toe of the dike embankment and at the west training wall of the spillway; flow under and between the granite steps of the cascade; trees and brush on the dike slopes and at the spillway abutments; accumulation of debris and vegetation in the spillway channel, and excavation along the edge of the reservoir.

Hydraulic analyses indicate that the existing spillway can discharge a flow of 1,015 cfs at El 549.8, which is the lowest point on the crest of the dike. An inflow test flood of 8,357 cfs will overtop the dike by 4.1 feet. The spillway can discharge only 13 percent of the outflow from the test flood before the dam is overtopped. In addition, the inflow from a 100-year frequency storm would result in a water surface at El 552, or about 2.2 feet above the crest of the dike. Limited information indicates that the dam was not overtopped during the 1955 floods. It is likely that the regulating effects of upstr am reservoirs reduces the peak flood flows at Patch Reservoir.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a

definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. The recommendations outlined below should be implemented within one year of receipt of the Phase I Inspection Report.

d. Need for Additional Information. Additional investigations to further assess the adequacy of the dike and spillway are outlined below in Section 7.2, Recommendations.

7.2 Recommendations. In view of the concerns over the continued performance of the dike and spillway, it is recommended that the Owner employ a qualified consultant to:

a. evaluate the stability of the dike,

b. evaluate the seepage at the downstream toe of the dike, and

c. conduct a more detailed hydraulic and hydrologic investigation for the entire drainage area. The purpose is to design a means to increase the discharge capacity of the existing spillway and to design a new outlet.

The recommendations on repairs and maintenance procedures are outlined below under Section 7.3 Remedial Measures.

7.3 Remedial Measures

a. Alternatives. An alternative to implementing the recommendations listed above and the maintenance procedures itemized below would be to lower the reservoir and breach or remove the dike.

b. Operation and Maintenance Procedures. The dike and spillway are not adequately maintained. It is recommended that the Owner accomplish the following items:

(1) install a gated outlet for lowering the reservoir in emergency situations,

(2) install riprap on the upstream face of the dike,

(3) remove all trees and brush from the dike,

(4) fill in excavated areas along the shore, and fill in any animal burrows,

(5) repair the break in the spillway crest block and seal against leakage through the cascade,

(6) clear accumulated debris in the spillway channel,

(7) institute a definite plan for surveillance and a warning system during periods of unusually heavy rains and/or runoff. The warning system should be coordinated with one at the upstream reservoirs in the watershed, because flooding or failure of the upper dams will have a severe effect on Patch Reservoir.

(8) implement a systematic program of inspection and maintenance. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances and be supplemented by additional inspections during and after severe storms. The slight seepage noted in the west abutment of the spillway training wall should be monitored and evaluated as part of the inspection program. All repairs and maintenance should be undertaken in compliance with all applicable State regulations.

APPENDIX A

PERIODIC INSPECTION CHECKLIST

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Patch Reservoir

DATE July 10, 1978

TIME 10:00 am

WEATHER sunny, warm

W.S. ELEV. 546.9 U.S. 541.5 [illegible] .S.

Assumed benchmark elevation 547, top of spillway

PARTY:

1. Ed Greco
2. Lyle Branagan
3. Carol Sweet
4. Susan Pierce
5. Dick Weber
6. Frank Swiokla
7. David Cole
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	Ed Greco, Dick Weber	
2.	Spillway	Lyle Branagan	
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT Patch Reservoir DATE 7-10-78

PROJECT FEATURE Dam NAME Ed Green

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT Crest Elevation	Dam/spillway is four-step granite cascade weir
Current Pool Elevation	546.9
Maximum Impoundment to Date	unknown
Surface Cracks	n/a
Pavement Condition	n/a
Movement or Settlement of Crest	crest flat
Lateral Movement	blocks slightly misaligned
Vertical Alignment	straight
Horizontal Alignment	relatively straight
Condition at Abutment and at Concrete Structures	Dam/Spillway joins natural ground at spillway training wall
Indications of Movement of Structural Items on Slopes	n/a
Trespassing on Slopes	tree cutting upstream on left abutment
Sloughing or Erosion of Slopes or Abutments	none
Rock Slope Protection - Riprap Failures	erosion beneath stones at toe settlement of stones
Unusual Movement or Cracking at or near Toes	n/a
Unusual Embankment or Downstream Seepage	n/a
Piping or Boils	n/a
Foundation Drainage Features	n/a
Toe Drains	n/a
Instrumentation System	none visible

PERIODIC INSPECTION CHECK LIST

PROJECT Patch Reservoir DATE 7-10-78

PROJECT FEATURE Dike NAME Ed Greco

DISCIPLINE Geotechnical NAME

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	varies from 549.8 to 553.9
Current Pool Elevation	546.9
Maximum Impoundment to Date	unknown
Surface Cracks	none visible
Pavement Condition	dirt path on crest
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	foot path, chipmunk holes
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or near Toes	
Unusual Embankment or Downstream Seepage	slight seepage at toe
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Patch Reservoir DATE 7-10-78

PROJECT FEATURE spillway NAME Ed Creco

DISCIPLINE Hydraulics NAME Lyle Branagan

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	approach to weir is stone-paved, 90° to pond
a. Approach Channel	
General Condition	fair to good
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	small tree on right abutment medium (12") tree on left abutment
Floor of Approach Channel	
b. Weir and Training Walls	dry and concrete masonry, step granite weir
General Condition of ~~Concrete~~ Stones	fair, some blocks dislodged
Rust or Staining	n/a
Spalling	n/a
Any Visible Reinforcing	n/a
Any Seepage or Efflorescence	n/a
Drain Holes	n/a
c. Discharge Channel	4' x 4' stones at bottom step
General Condition	fair to poor, small scattered stones
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	small to medium trees growing in channel
Floor of Channel	vegetation and debris
Other Obstructions	none

APPENDIX B

PLAN OF DAM AND PREVIOUS INSPECTIONS

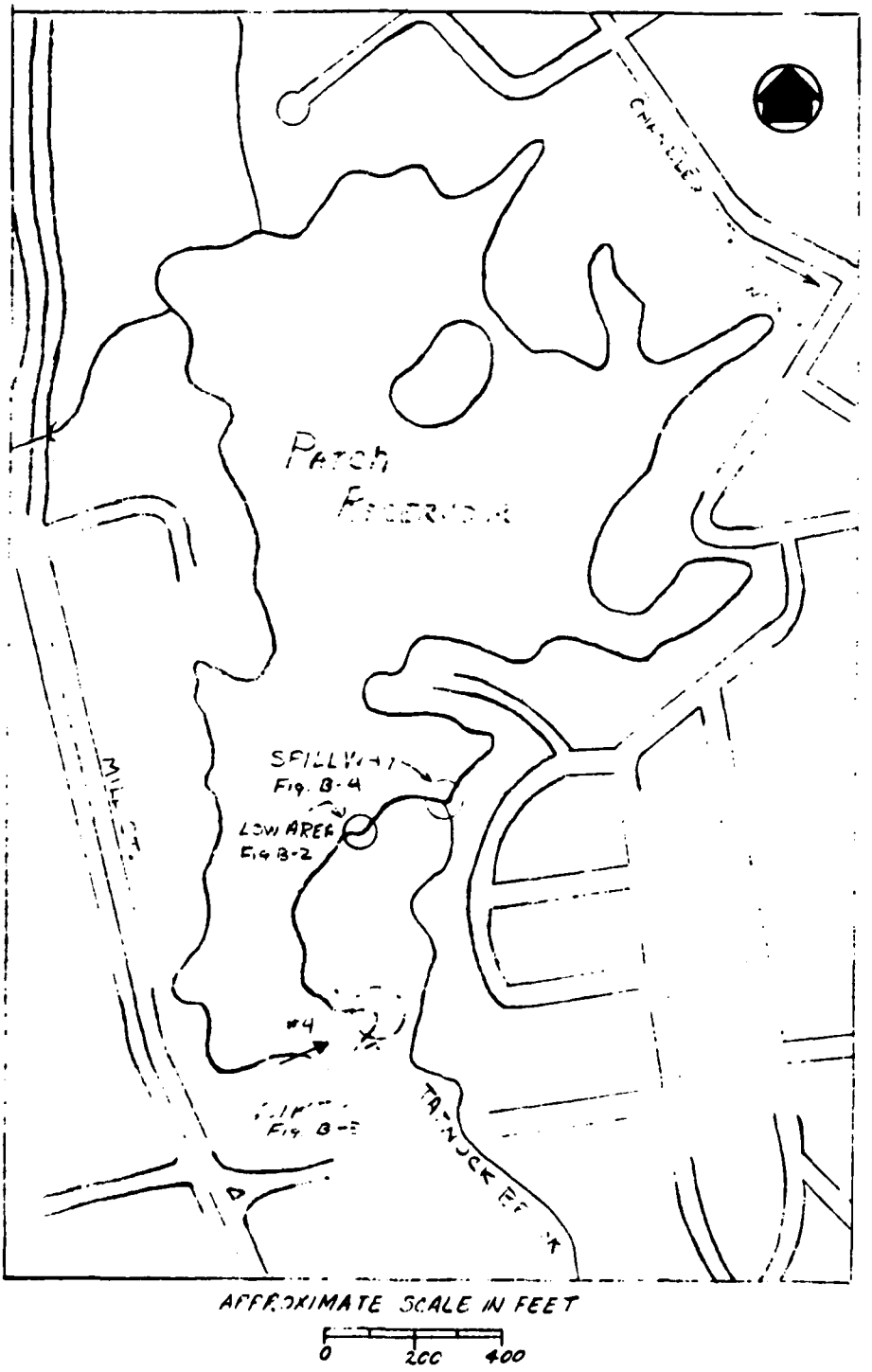
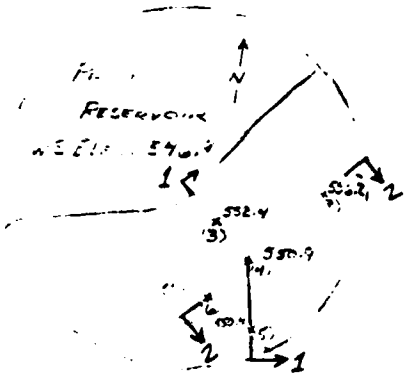
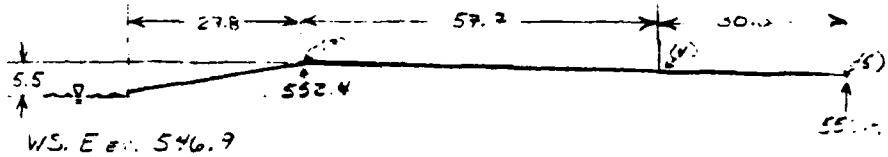


FIGURE B-1. SCHEMATIC LOCATION PLAN

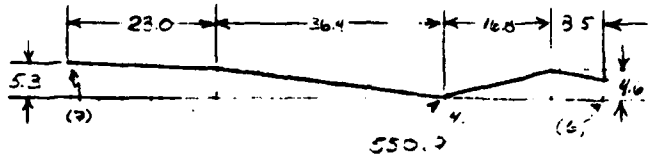


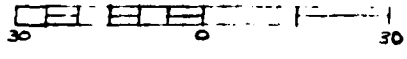
LOCATION MAP
(NOT TO SCALE)

SECTION 1-1



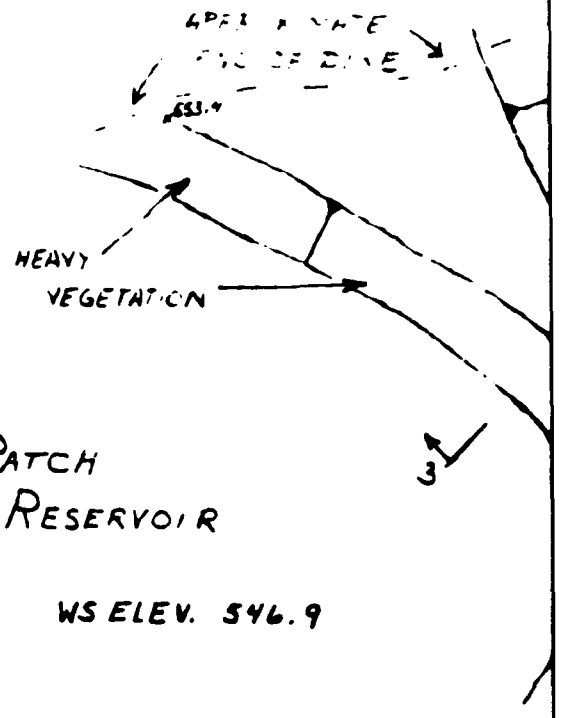
SECTION 2-2





Scale in Feet

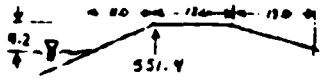
FIGURE B-2. CROSS SECTION-LOW AREA



NOTES.

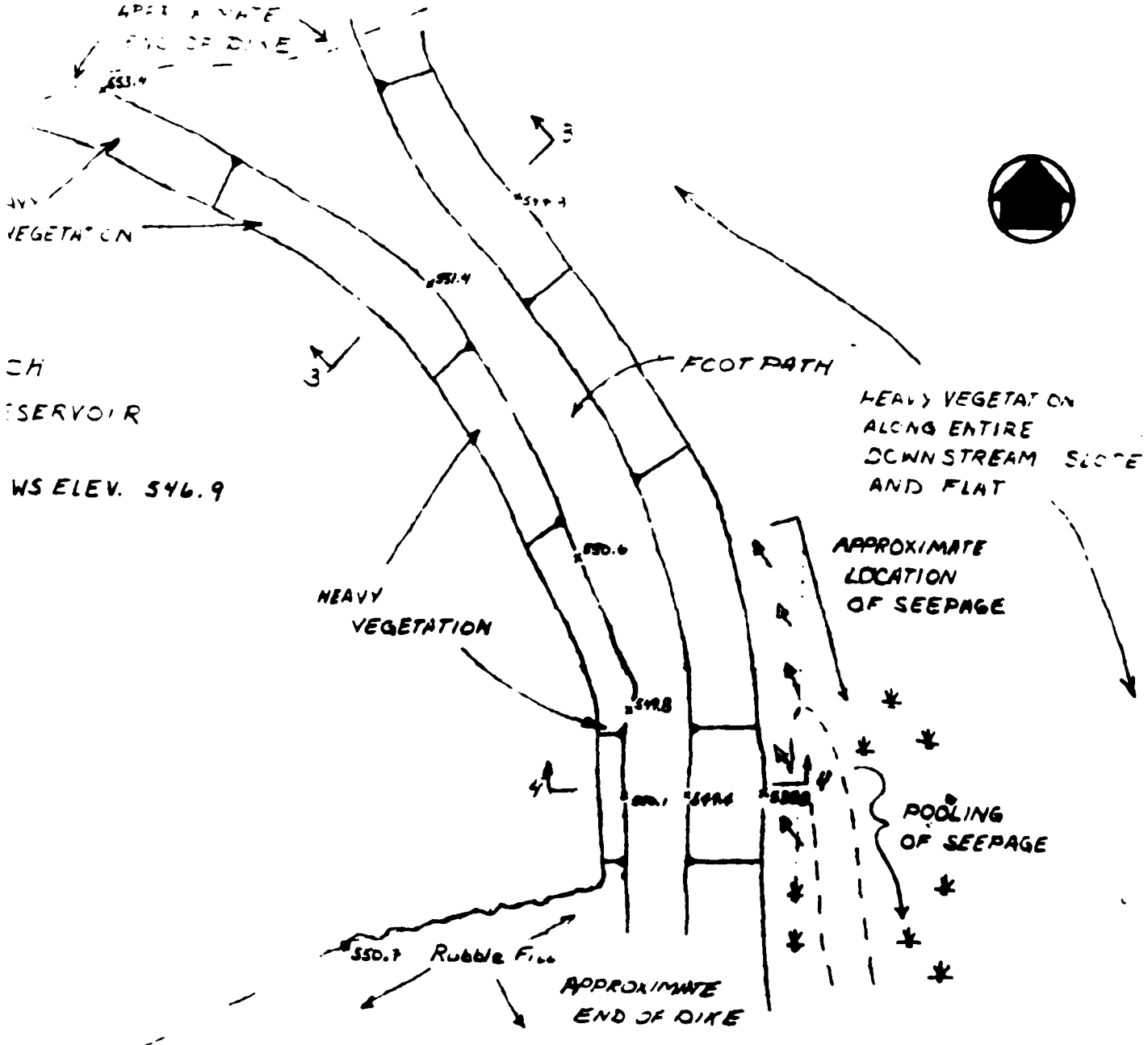
1. ELEVATIONS SHOWN ARE REFERENCED TO ASSUMED BENCHMARK ELEV. 548.0 (M.S.L.) ON SPILLWAY CREST (SEE FIGURE B-4)
2. INFORMATION SHOWN BASED ON FIELD SURVEY OF JULY 10, 1978.
3. ⚓ DENOTES SEEPAGE

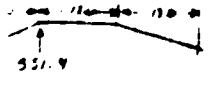
APPROXIMATE
SHORELINE



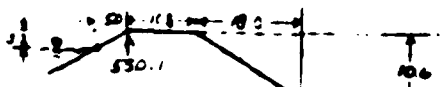
SECTION 3-3

Metcalf & Eddy, Inc.

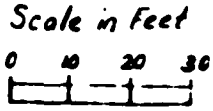




SECTION 3-3



SECTION 4-4 MARSH



(2)

FIGURE B-3. DIKE PLAN AND SECTIONS

TOWN OR CITY *Worcester* DECREE NO. *133, 234* PLAN NO. *[illegible]*

LOCATION *Patch Reservoir - Mill St.* C.C. DOCKET NO. *3-18*

DESCRIPTION OF DAM

Back spillway 6:1 slope — El. 100'±

Type *Concrete Corewall. Earthern Embankment.*

Length *400'±*

Height *20'±*

Thickness top *20'* *abt. 32.6*

" bottom *70' emb. spillway = 32'±*

Downstream Slope *1¾:1*

Upstream " *1¾:1*

Length of Spillway *=70'±* *El. crest = 96.0*

Size of Gates *24" c.i. Also 18" c.i. El. 78.0*

Location of Gates *Center of Embankment.*

Flashboards used *None*

Width Flashboards or Gates

Dam designed by *F.L. Allen C.E. March 1896*

" constructed by

Year constructed

GENERAL REMARKS

Owned by Independent Ice Co.
Vol. 28 P. 373 April 21, 1896
Inspected - Aug. 15. 1925 - L.O. Marden.
Second Inspected 3-18-26 L.O. Marden
Inspected: 9-3-28 " "
" 12-17-31 " "
" 4-30-32 " "
" 7-29-32 " "
" 3-19-36 - W.O.L., M.F.H.

DESCRIPTION OF RESERVOIR & WATERSHED

Name of Main Stream *Tatnuck ~~brook~~*

" " any other Streams *~~Owned by Mill Park, Inc., Tom F. Dillon & Frank Clarkson 776 Main St, Worcester~~*

Length of Watershed

Width " "

Is Watershed Cultivated

Percent in Forests *1957 - R. & H. Machinery Co.*

Steepness of Slope *1055 Southbridge St - Worcester*

Kind of Soil *Rocky - hardpan!*

No. of Acres in Watershed *7.33 Sq M*

" " " " Reservoir *55.*

Length of Reservoir

Width " "

Max Flow Cu. Ft per Sec.

Head or Flashboards-Low Water

" " " -High " *Orig. Owner William Patch*

GENERAL REMARKS

Docket #133. Mar. 1892 Meeting. Filed: Mar. 8, 1892.
Traced by: H.D. Vasselin. Feb. 20, 1936.
Checked by: L.O. Marden. " " "
Attested by: William C. Bowen - C. of C. - Feb. 21, 1936
(Plan of Proposed Changes.)
Docket #234. Meeting Mar. 1896 Filed: April 21, 1896
Traced: M.F. Hunt - Mar. 3, 1936. Attested by:
Checked: L.O. Marden - " 4, " W.C.B. C. of C.
F.L. Allen, C.E., March, 1896. (over)

PREVIOUS INSPECTIONS (PARTIAL LISTING)

COPY OF INSPECTION CARD ON FILE AT THE MASSACHUSETTS DEPARTMENT OF PUBLIC WORKS, DISTRICT OFFICE, WORCESTER.

Inspected: Nov. 17, 1938 - L. H. Spofford
" : Dec. 9, 1940 " "
" Dec. 7, 1942. L.O.M. - J.F.C.
" Dec. 15, 1944 · L.O.M. - W.O.L.
" DEC. 11, 1945 - W.O. Lindquist
" June 30, 1950 LOM
" June 16, 1948 - LOM

OWNER - Mill Park, Inc. c/o Harry Friedburg, President
Pullman Rd., Worc

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/Town WORCESTER Dam No. 3-14-348-11

Name of Dam PATCH RESERVOIR Inspected by MULLAHY + DONAHUE

Date of Inspection 1-10-73

2. Owner/s: per: Assessors _____ Prev. Inspection ✓

Reg. of Deeds _____ Pers. Contact _____

1. MILL PARK INC % HARRY FRIEDBERG, PRES. PULLMAN RD. WORC.
Name St. & No. City/Town State Tel. No.

2. _____
Name St. & No. City/Town State Tel, No.

3. _____
Name St. & No. City/Town State Tel. No.

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name: St. & No.:

City/Town: State: Tel.No.:

4. No. of Pictures taken _____

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate ✓

3. Severe _____ 4. Disastrous _____

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic ✓ Manual _____

Operative _____ yes; _____ No.

Comments: SPILLWAY CONTROLED

7. Upstream Face of Dam: Condition:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

or Comments:

8. Downstream Face of Dam:

Condition: 1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments:

9. Emergency Spillway: NONE

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments:

10. Water Level at time of inspection: 3 ft. above ___ below ✓

top of dam ✓ principal spillway _____

other _____

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment YES

Animal Burrows and Washouts NONE

Damage to slopes or top of dam NONE

Cracked or Damaged Masonry NONE

Evidence of Seepage NONE

Evidence of Piping NO

Erosion NONE

Leaks NONE

Trash and/or debis impeding flow SOME

Clogged or blocked spillway NO

Other _____

DAM NO. 3-14-348-11

12. Remarks & Recommendations: (Fully Explain)

THE MAJOR PORTION OF THE DAM ITSELF IS IN GOOD CONDITION, THE FIELDSTONE RETAINING WALLS ARE INTACT, THE GRANITE BLOCK SPILLWAY AND STEPS HAVE REMAINED FUNCTIONAL AND SHOW NO SIGNS OF WEAR. TREES AND BRUSH GROWING ON DOWNSTREAM EMBANKMENTS SHOULD BE REMOVED. THE CHANNEL PAVING BELOW THE SPILLWAY PREVENTS ERODING OF STREAMBED.

13. Overall Conditions:

1. Safe ✓
2. Minor repairs needed ✓
3. Conditionally safe - major repairs needed
4. Unsafe
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list

DESCRIPTION OF DAM

DISTRICT 3

Submitted by _____ Dam No. 14-348-11

Date 1/10/73 City/Town WORCESTER

Name of Dam PATCH RESERVOIR

1. Location: Topo Sheet No. 20D

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: _____ Year/s of subsequent repairs _____

3. Purpose of Dam: Water Supply _____ Recreational ✓

Irrigation _____ Other _____

4. Drainage Area: 9.33 sq. mi. _____ acres

5. Normal Ponding Area: 55 acres; Ave. depth _____

Impoundment: _____ gals; _____ acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

10 i.e. summer homes, etc. _____

7. Dimensions of Dam: Length 600'± Max. Height 8'

Slopes: Upstream Face 2½:1 & 3:1

Downstream Face ½:1

Width across top 30'

8. Classification of Dam by Material:

Earth ✓ Conc. Masonry _____ Stone Masonry ✓

Timber _____ Rockfill _____ Other _____

9. A. Description of present land usage downstream of dam:

_____% rural; 100 % urban.

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes ✓ no _____.

DAM NO. 3-14-348-11

10. Risk to life and property in event of complete failure.

No. of people 50.

No. of homes 10.

No. of Businesses NONE.

No. of industries NONE. Type _____

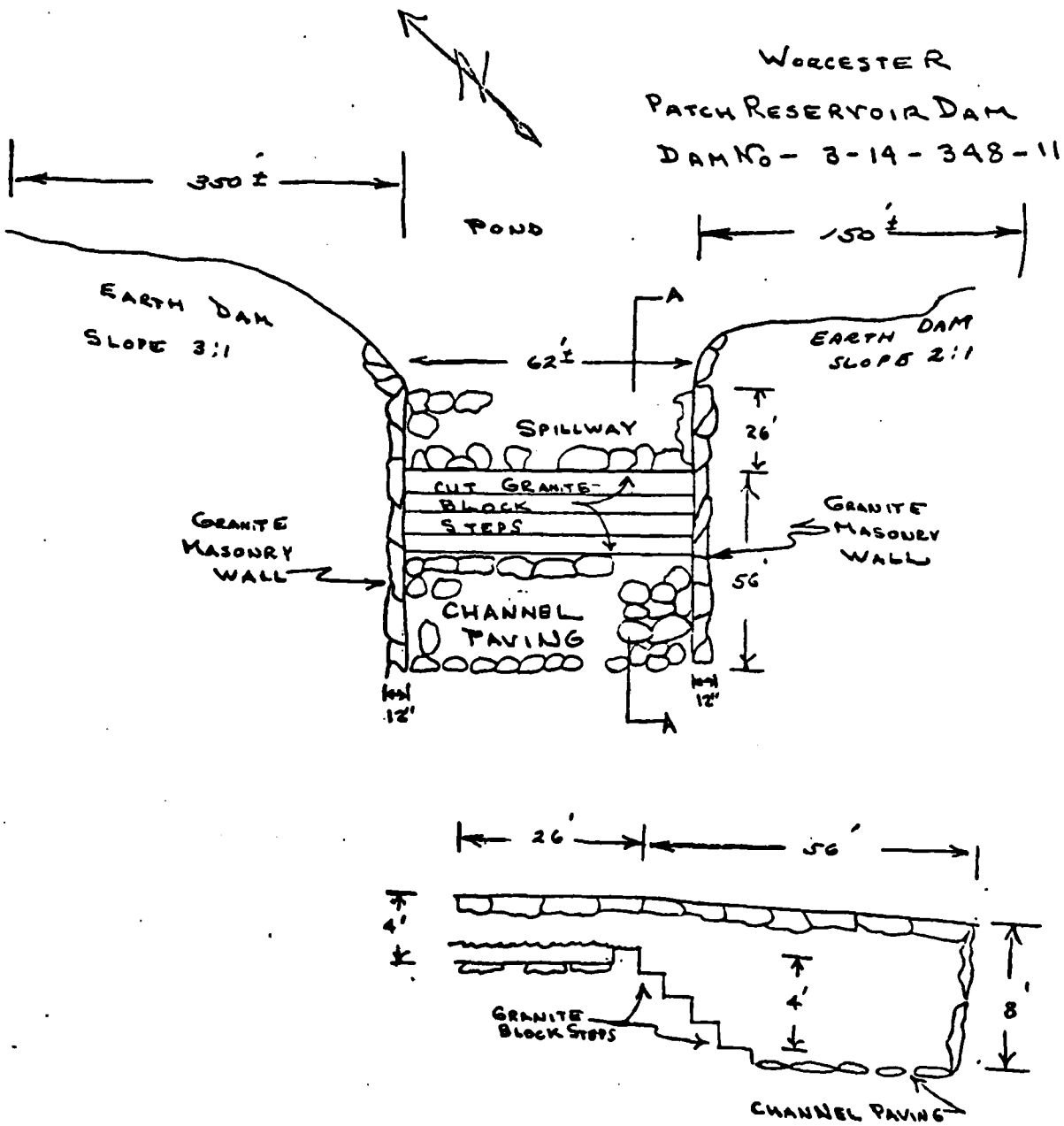
No. of utilities NONE. Type _____

Railroads NO.

Other dams COES RESEVOIR DAM

Other _____.

11. Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheets. JUNE ST. TO GLENDALE ST. TO PATCH RESEVOIR DRIVE. DAM IN BACK OF #29 PATCH RESEVOIR DR.


WORCESTER
PATCH RESERVOIR DAM
DAM NO - 8-14-348-11
350 ±
POND
150 ±
EARTH DAM
SLOPE 3:1
62 ±
A
EARTH DAM
SLOPE 2:1
SPILLWAY
26'
CUT GRANITE BLOCK STEPS
GRANITE MASONRY WALL
GRANITE MASONRY WALL
56'
CHANNEL PAVING
12"
12"
A
26'
56'
4'
4'
8'
GRANITE BLOCK STEPS
CHANNEL PAVING

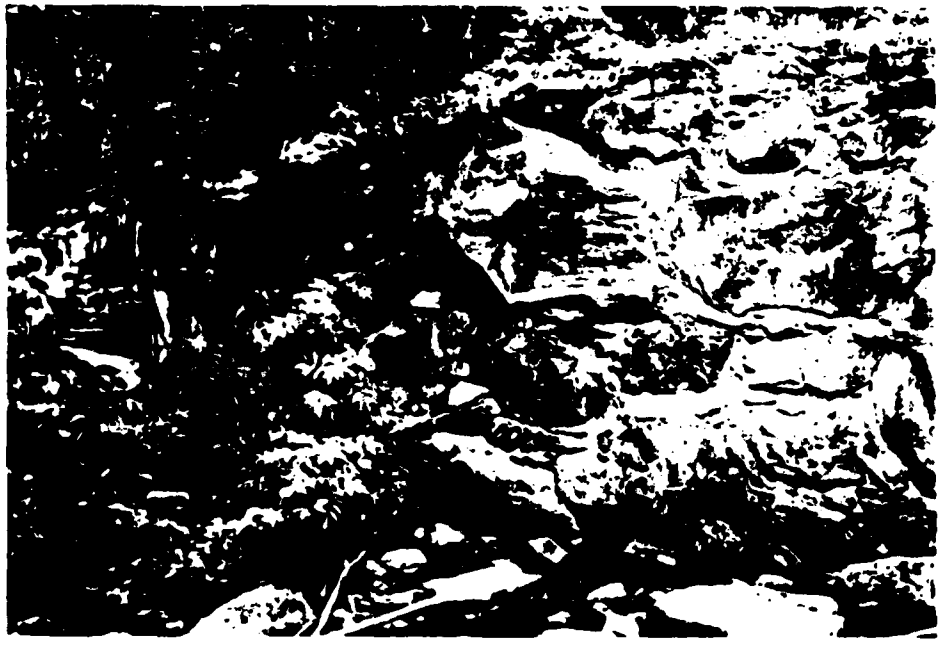
SECTION A-A

APPENDIX C

PHOTOGRAPHS

NO. 1 SPILLWAY WEIR

NO. 2 CHANNEL DOWNSTREAM OF SPILLWAY

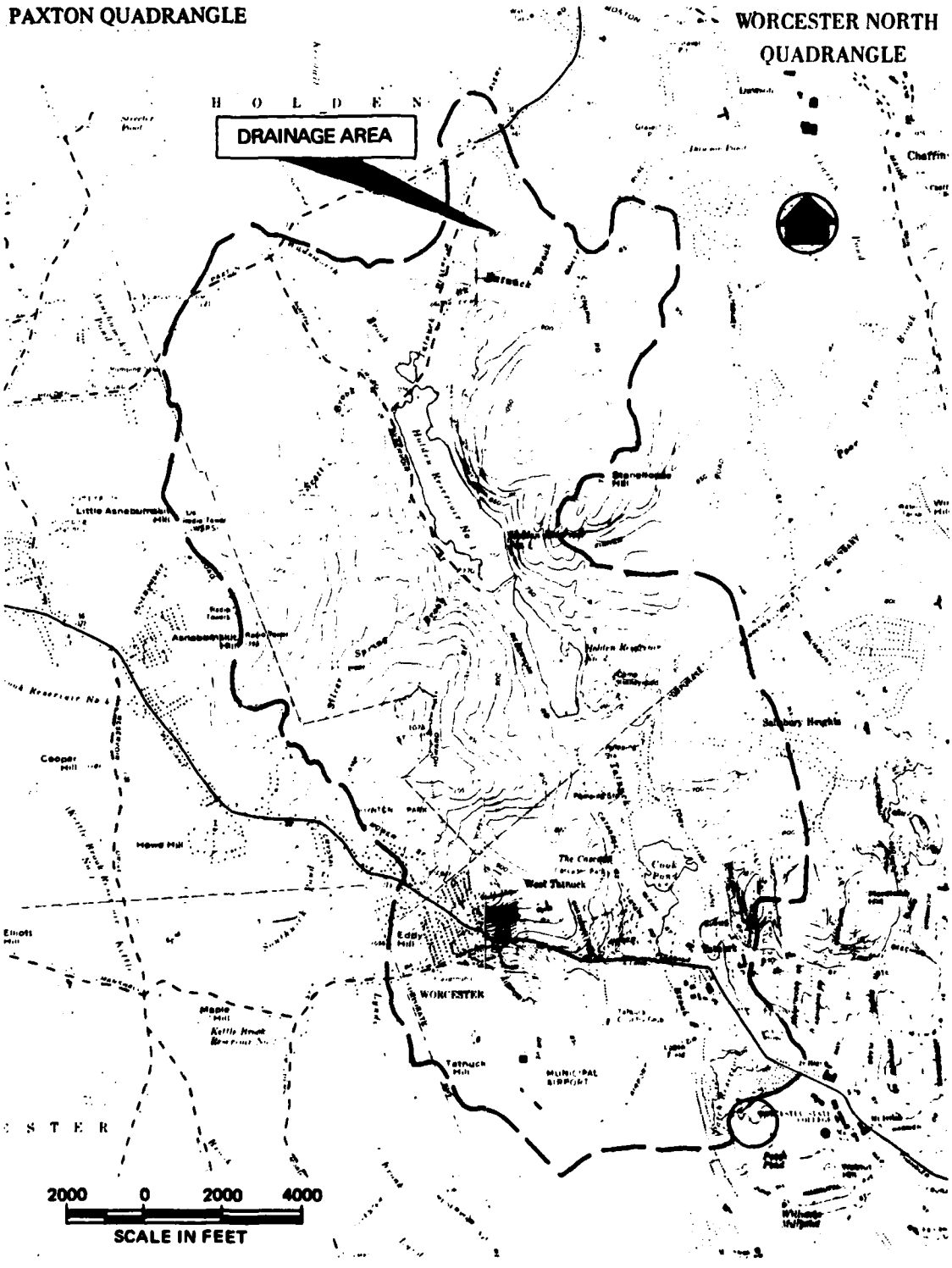


NO. 3 DETAIL OF WEST SIDEWALL OF SPILLWAY

NO. 4 DIKE SECTION – FIGURE B-3

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

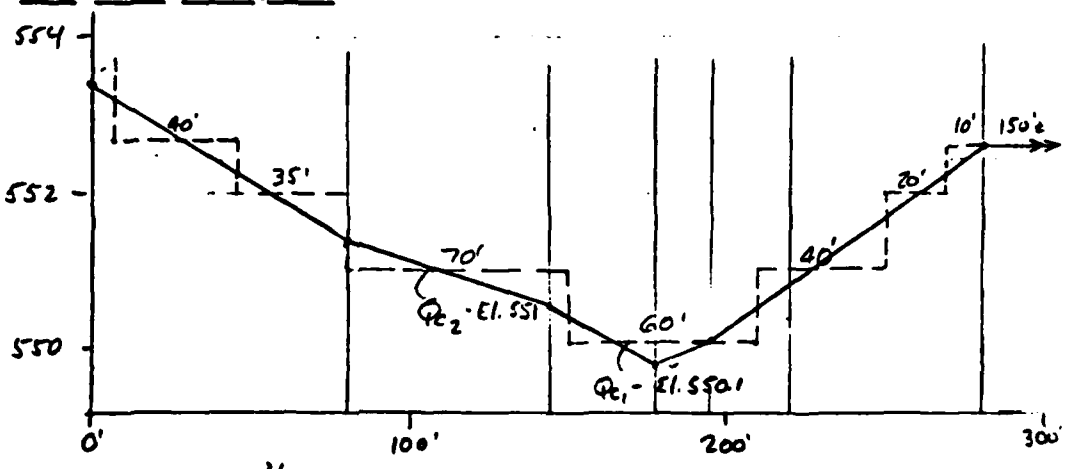


PATCH RESERVOIR DRAINAGE AREA

Project NAT. REVIEW NON FED. DAMS Acct No. 5864 Page 1 of 5
Subject WORCESTER MASS AREA Comptd. By LEB Date 7/17/79
Detail PATCH RESERVOIR DAM Ck'd. By RW Date 8/2/79

(I) Flow Over Dike Section and Spillway – plus Storage

A- Dike Section



$Q_{c_1} = 153 (H_1')^{3/2}$ above 550.1

$Q_{t_2} = 280.5 (H_2')^{3/2}$ • 551.0 Based on $q = 2.55 (H')^{3/2}$

$Q_{c_3} = 140 (H_3')^{3/2}$ • 552.0 ; $Q_{c_4} = 510 (H_4')^{3/2}$ above 552.7

B- Spillway

Top is 6" wide masonry block. Use "Hydraulic Tables" by Williams & Hazen, assume sharp edge weir flow, with $H = 6'$ (for pond level) & $L = 0.9(69.6') = 62.6'$. Crest elev. 547.0

C-Summary (Pond area ≈ 0.05 mi² - DA = 8.9 mi²)

Pond Elev	Q_s	Q_{c_1}	Q_{c_2}	Q_{c_3}	Q_{c_4}	$Q_{Tot.}$	Storage in mi²	Storage in. on D.A.
547.5	76	—	—	—	—	76	0.3	.034
548.0	210	—	—	—	—	210	0.6	.067
549.0	603	—	—	—	—	603	1.2	.135
550.0	1131	—	—	—	—	1131	1.8	.202
550.5	1441	39	—	—	—	1480	2.1	
551.0	1782	131	—	—	—	1913	2.4	.270
551.5	2150	253	100	—	—	2503	2.7	
552.0	2544	401	280	—	—	3225	3.0	.337
552.5	2965	569	516	49	—	4099	3.3	.371
553.0	3414	756	794	140	84	5188	3.6	.404
553.5	3850	959	1109	257	365	6540	3.9	.438
554.0	4302	1178	1458	396	756	8090	4.2	.472
554.5	4771	1412	1837	553	1232	9805	4.5	.506

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(II) Peak Inflow Test Flood

Patch Res. recieves major flow from Cook Pond, plus 1.8 sq. miles of direct trib. area. Add flows from each source to obtain test flood for total D.A. = 8.9 mi²

Slope — Average Say 4%
Omit Ponds & Swamps - Say 0% [Storage in Patch Res later]

Disch. between Rolling & Mount. - Say 2350 cfs/mi²

Direct Inflow Test Flood = $2350(\frac{1}{2})(1.8) = 2115$ cfs
Peak Outflow from Cook Pd = 6242 "
Inflow Test Flood = 8357 cfs.

(III) Outflow Relation

$Q_F = 8357\left(1 - \frac{S_F}{9.5}\right) = 8357 - 880(S_F)$ [S_F = Pond Storage in inches over D.A.]

see Sect. (IV) below.

(IV) 100 Year Flood Flow

6 hour rainfall for Std. "100 yr." storm = 4.7 inches
6 hour infiltration @ 0.18 in./hr. = 1.1 inches total

$Q_{100_D} = 4230\left(\frac{4.7-1.1}{19-1.1}\right) = 850$ cfs
Q_{100} from Cook Pd. = 2560 "
Total Q_{100} inflow = 3410 cfs

(V) Storage Reduction in Discharge

A. Inflow Test Flood: $Q_F = 8357\left(1 - \frac{S_F}{9.5}\right) = 8357 - 880S = F_{TF}$
El. 553.5 - Q_{F_1} = 7971 > $Q_{Tot.}$ } Plot on Disch. Curve
El. 554.0 - Q_{F_2} = 7942 < $Q_{Tot.}$ }
From Disch. Curve Q_{out} = 7950 cfs w/ Pond El. 553.9

B. 100 yr Flood: $Q_{100_F} = 3410\left(1 - \frac{S_F}{4.7}\right) = 3410 - 726S = F_{100}$
El. 552.0 - F_{100} = 3165 ≈ $Q_{Tot.}$ } Plot on Disch. Curve
El. 552.5 - F_{100} = 3140 < Q_{Tot} }
From Disch. Curve Q_{out} = 3180 cfs w/ Pond El. 551.95

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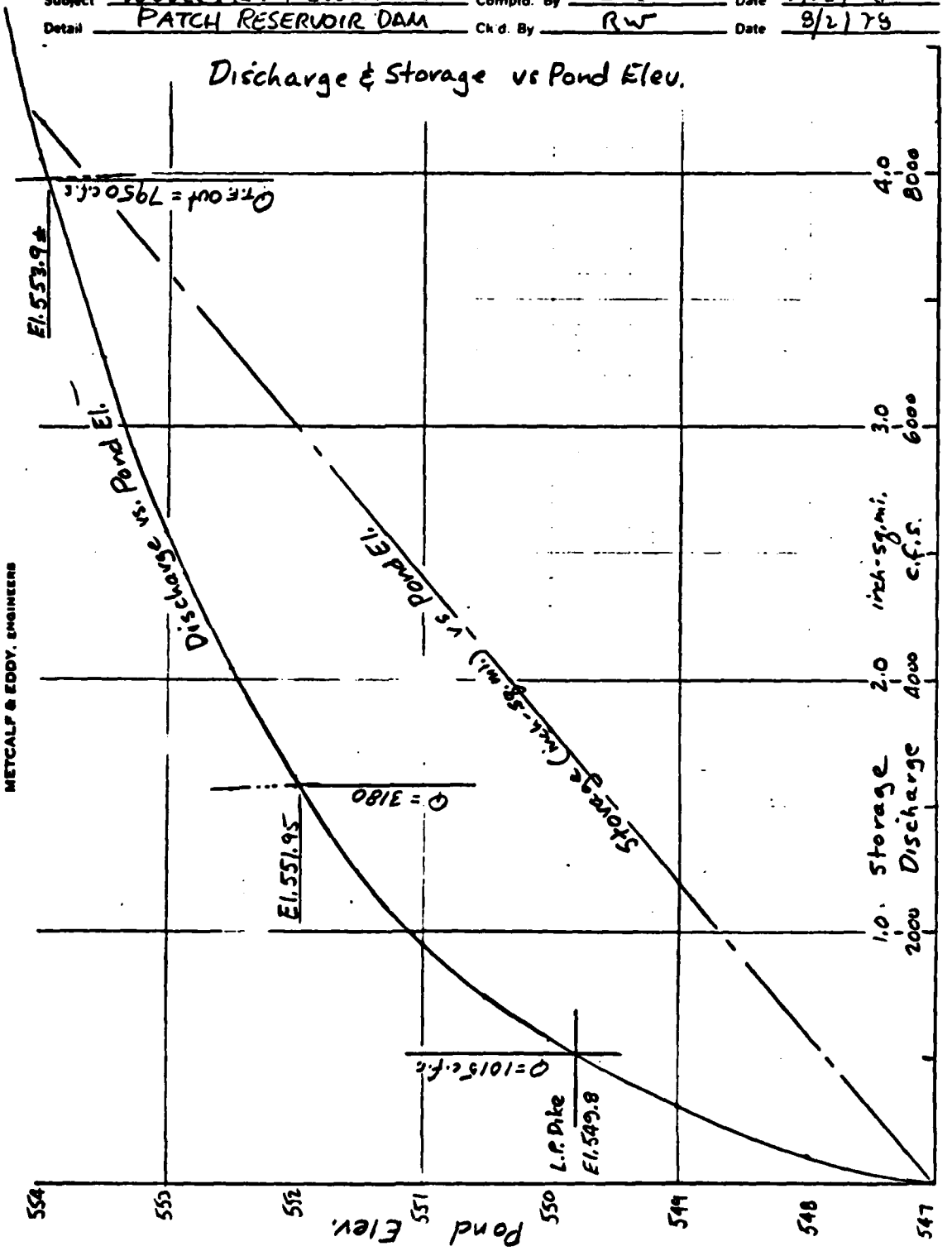
Subject Worcester Mass. Area Compld. By LEB Date 7/18/79

Detail PATCH RESERVOIR DAM Ck'd. By RW Date 8/2/79



Project NAT. REVIEW NON FED. DAMS Acct. No. 5864 Page 4 of 5
Subject WORCESTER MASS AREA Comptd. By LEB Date 7/18/79
Detail PATCH RESERVOIR DAM Ck'd. By RW Date 8/2/79

(VI) Flow Over Dike Crest

Pond At Elev. 553.9
Low Pt. on Dike 549.8
Depth of Flow 4.1'

$$q = 2.55(4.1)^{3/2} = 21.2 \text{ cfs/ft}$$

Critical Depth = 2.4' ; Critical Vel. = 8.8 fps

(VII) Failure of Dike - Say @ Pond El. 553

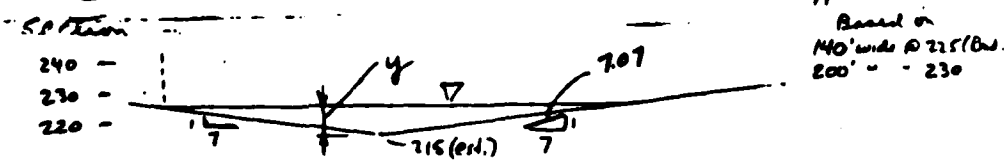
Length Most Subject to Failure - 180'
Max Depth to Bot. Dike 553 - 539.5 = 13.5'

$$Q_{P_1} = \frac{8}{27}(0.4 \times 180)\sqrt{32.2}\,(13.5)^{1.5} = 6000 \text{ cfs}$$

Vol. Storage @ Failure = $S = 90 + 640(.05)6 = 282$ Ac. ft.

Use narrows on Patch Pond (now drained) as typical

Section



Adjusted cross section

$A = 7y^2$
$P = \frac{7.07}{7}(14)y = 14.14y$ } $R = \frac{y}{2.02}$

$n = 0.05$, $S = \frac{230-210}{2200} = .0091$; $Q = AR^{2/3}(2.84)$

y	A	P	$R^{2/3}$	Q	Vel.
2	28	—	0.993	79	2.82
4	112	—	1.577	502	4.48
6	252	—	2.066	1479	5.87
8	448	—	2.503	3185	7.11
9	567	—	2.708	4360	7.69
10	700	—	2.905	5775	8.25
11	847	—	3.095	7445	8.79

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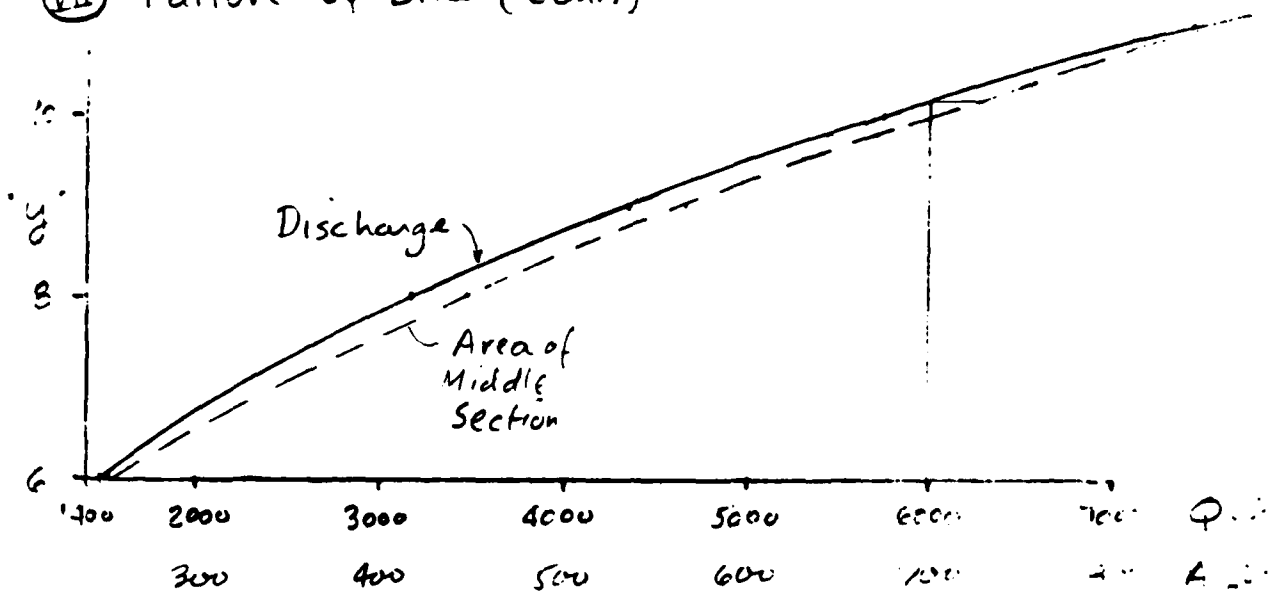
Project Nat. Review Non Fed Dams Acct. No. 5864 Page 5 of 5
Subject Worcester Mass Area Comptd. By LEB Date 7/18/78
Detail PATCH RESERVOIR DAM Chk'd. By RW Date 8/2/78

(VII) Failure of Dike (Cont.)



Length of 1st reach 1600 ft

$Q_{P_1} = 6000$ cfs, $y = 10.2$, $A_1 = 725\ ft^2$, $Vol_1 = 26.6$ Ac. ft

Trial $Q_{P_2} = 6000\left(1 - \frac{26.6}{282}\right) = 5434$ cfs ; $A_2 = 670\ ft^2$

$Vol_2 = 24.6$ Ac. ft., Ave Vol = 25.6

$$Q_{P_2} = 6000\left(1 - \frac{25.6}{282}\right) = 5455 \text{ cfs}$$

$y_2 = 9.8'$, Area $= 670\ ft^2$, $\bar{V}el = 8.14$

$$\text{Travel time} = \frac{282(43560)}{5455 \text{ (conversion)}} = 1.25 \text{ hours}$$

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APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST	(7) STATE	(8) COUNTY	(9) CONGR DIST	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY	MO	YR
MA	122	NED	MA	027	03				PATCH RESERVOIR DAM	4216.1	7151.1	10	AUG	78

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	PATCH RESERVOIR

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	06	TR-BLACKSTONE RIVER	WORCESTER	0	172300

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)	(27) DIST	(28) OWN	(29) FED R	(30) PRV/FED	(31) SCS A	(32) VER/DATE
RFPG	1896	R	11	11	205	120	NED	N	N	N	N	10AUG78

(33) REMARKS

(34) O/S HAS	(35) SPILLWAY CREST LENGTH	(36) TYPE	(37) WIDTH (FT.)	(38) MAXIMUM DISCHARGE (FT.)	(39) VOLUME OF DAM (CY)	(40) POWER CAPACITY INSTALLED (MW)	PROPOSED (MW)	(41) NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	200	U	70	1015	1400											

(42) OWNER	(43) ENGINEERING BY	(44) CONSTRUCTION BY
WORCESTER DPW		

(45) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

(46) INSPECTION BY	(47) INSPECTION DATE DAY	MO	YR	(48) AUTHORITY FOR INSPECTION
METCALF & EDDY, INC	10	JUL	78	PL 92-367

(49) REMARKS